U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

DOCUMENT RETRIEVAL REQUEST FORM

Requester's Name: Brian Q Le	Case Serial Number:	Art Unit/Org.: 2623
Phone: 305-5083	Fax:	Building: PK1 4B40	Room Number:
Class/Sub-Class:		
Date of Request: 3-15-04	Date Needed By: Rush	
Paste or add text of citation or bibliography: Paste Citation	Only one request per form. Original copy only. ☐	

Author/Editor:			
Journal/Book Title:	SPIE v. 3882		
Article Title:			
Volume Number:	Report Number:	Pages:	158-168
Issue Number:	Series Number:	Year of Publication:	1999
Publisher:			
Remarks:			

Staff Use Only

Monthly Accession Number:

Library Action	PTO		LC		NAL		NIH		NLM		NIST		Other	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Local Attempts														
Date	3/15													
Initials	KeJ													
Results	yes													
Examiner Called	EJournal													
Page Count														
Money Spent														

		Source	Date
Remarks/Comments 1st and 2nd denotes time taken to a library O/N – Under NLM means Overnight	Ordered From:		
	Comments:		

PTO-XXXX (2-96)

BEST AVAILABLE COPY

USCOM-DC

Author: Klymenko, Victor; **Rash, Clarence E.**
Corporate Source: UES, Inc, Fort Rucker, AL, USA
Conference Title: Proceedings of the 1995 51st Annual Forum. Part 2 (of 3)
Conference Location: Fort Worth, TX, USA Conference Date: 19950509-19950511
E.I. Conference No.: 45376
Source: Annual Forum Proceedings - American Helicopter Society v 2 1995. American Helicopter Soc, Alexandria, VA, USA. p 1450-1465
Publication Year: 1995
CODEN: PFASDL ISSN: 0733-4249
Language: English

Title: **Human factors** evaluation **of visual** field **-of-** view **effects of partial binocular overlap designs in helmet-mounted** displays
Author: Klymenko, Victor; **Rash, Clarence E.**
Abstract: The **Helmet Integrated Display Sight System** (HIDSS) is a new binocular **helmet** -mounted **display** (**HMD**) under development by the U.S. Army for the RAH-66 Comanche helicopter. The HIDSS design uses a partial binocular overlap **field** -of- **view** (FOV) instead of a full overlap FOV where each of the two eyes sees the entire FOV. A full overlap FOV would have been an ideal optical **display** design configuration; however, technical and human factor considerations have limited the size of the FOV for each eye. The partial overlap **display** design overcomes this limitation by sharing the larger sensor FOV between the two eyes. Here a portion of the outside scene is **displayed** to both eyes, and each eye independently sees an additional portion. This has led to a number of visual human factor issues including the effect of this **display** design on the appearance of the FOV, on target **detectability** and on the binocular alignment of the two **images** . We review ongoing work conducted in our lab on the perceptual and performance effects of...
Descriptors: Instrument **displays** ; Helicopters; Human engineering; **Evaluation** ; Design; Optical devices; **Image** sensors; Imaging systems; **Image** intensifiers (electron tube); Military applications
Identifiers: **Helmet integrated display sight systems** ; Optical **display** design configuration; Binocular **helmet** mounted **display** ; Visual human factor; **Field of view** ; Binocular overlap design; Full overlap **field of view** ; Target **detectability** ; Binocular alignment; Night vision

29/3,K/9 (Item 1 from file: 144)
DIALOG(R)File 144:Pascal

14478792 PASCAL No.: 00-0140369
Characterization of sub-0.18 mu m critical dimension pattern **collapse for yield improvement**
Process, equipment, and materials control in integrated circuit manufacturing V : Santa Clara CA, 22-23 September 1999
TOM ZHONG; GURER E; LEE E; HONG BAI; GENDRON B; KRISHNA M; **REYNOLDS R**
TOPRAC Anthony J, ed; DANG Kim, ed
Silicon Valley Group, Track Division, 541 E. Trimble Rd., San Jose, CA 95131, United States
International Society for Optical Engineering, Bellingham WA, United States.
Process, equipment, and materials control in integrated circuit manufacturing. Conference, 5 (Santa Clara CA USA) 1999-09-22
Journal: SPIE proceedings series, 1999, 3882 158-168
Language: English

Characterization of Sub-0.18μm Critical Dimension Pattern Collapse for Yield Improvement

Tom Zhong*, Emir Gurer, Eddie Lee, Hong Bai, Bill Gendron, Murthy Krishna
Reese Reynolds

Silicon Valley Group, Track Division, 541 E. Trimble Rd. San Jose, CA 95131

Process Technology Group

ABSTRACT

In this study, we demonstrate that surface-resist interface interactions are becoming more crucial in DUV lithography as we enter deep into the sub-wavelength era of smaller critical dimension (CD) size and high aspect ratio. This interaction reveals itself as an adhesion reduction of the resist film due to the smaller contact area between the feature and the substrate. Considerable yield improvements in a manufacturing environment can be realized if pattern collapsing of smaller features is prevented by means of proper priming. In addition, next generation photoresist processing equipments must be able to deliver excellent on-wafer results with minimum chemical consumption as environmental health and safety (EHS) requirements are better appreciated in the marketplace. HMDS is not only highly toxic but it is also a prime threat to CD control of most deep ultra violet (DUV) photoresists used for sub-0.18μm design rules. The by-product NH_3 created during priming process with HMDS can neutralize the photo-acid created during the exposure step. There are many technical opportunities in this usually neglected priming process step.

In this study, we characterized sub-0.18μm isolated line pattern collapse for UV5 resist on bare Si wafers by using a scanning electron microscope (SEM). The smallest line width printability on wafers primed with different contact angles was analyzed by using both top down and cross section SEM images. Our results show that there is a strong effect of substrate surface and film interface interaction on device yields. More specifically, there is a strong correlation between pattern integrity of features down to 115nm and vapor prime process conditions. In general, wafers with higher contact angle can support smaller line widths. These results suggest that higher contact angle than the current specification will be required for sub-0.1μm design rule for improved yield. An alternative material to HMDS will probably be needed due to more stringent future requirements and weak bonding characteristics of HMDS. Based on the result of this study, we propose an HMDS consumption reduction scheme for line-widths above 0.2μm. There are many priming-related modular and system level technical enhancements that can be designed in the next generation photoresist processing tools in order to extend 248nm lithography towards smaller feature sizes.

Keywords: Pattern collapse, adhesion, contact angle, SEM, HMDS, amine contamination, yield improvement, critical dimension (CD), 248 nm lithography

1. INTRODUCTION

Various semiconductor industry road maps predict that optical lithography can ultimately pattern feature sizes as small as 50nm in a manufacturing environment. So far, most research focus has been directed to develop advanced exposure tools and resists that will enable patterning of smaller lines. In comparison, much less effort was spent to understand the significance of surface and film interface interactions to support such small features with a special emphasis of modern production oriented lithography. There are many surface-related problems that have strong impact on the results of DUV lithography. For example, adhesion reduction-induced pattern collapse of small and high aspect ratio features is an important yield problem for 248nm technology. The adhesion problem is one of the well documented problems of the next generation

* Correspondence: Email: zhongt@svg.com; Telephone: (408) 432-6833; Fax: (408) 325-6781

Part of the SPIE Conference on Process, Equipment, and Materials Control in Integrated Circuit Manufacturing V • Santa Clara, California • September 1999
SPIE Vol. 3882 • 0277-786X/99/$10.00

193nm chemically amplified resists. Many studies have shown that the most commonly used priming agent HMDS (hexamethyldisilazane) does not actually increase the mechanical adhesion between the resist film and the substrate.[1-4] Others have predicted that HMDS is unlikely to be the optimal choice at feature dimensions below 0.25µm.[5] However, it remains to be the material of choice for 193nm photolithography, partly because there is not a better alternative. Therefore it is essential to understand the contribution of the surface interactions to the pattern collapsing phenomena within the framework of the current priming technology. This approach will enable better new generation photoresist processing tools that meet future technology requirements and surpass them.

Figure 1 shows HMDS priming mechanism. The non-polar trimethylsilyl groups produced by HMDS reaction with silanol attaches itself to the resist surface by a weak Van der Waals interaction. This molecular adsorption increases adhesion of the resist indirectly by preventing aqueous solutions (such as developer and DI water) from penetrating the interface between photoresist and the substrate. It does not however, increase the mechanical adhesion between the resist film and the substrate.[2] In addition, HMDS is highly toxic and thermally activated HMDS priming reaction is the largest source of NH_3 and other amines as reaction by products which necessitate the use of chemical filtration in DUV lithography. The CD and yield impact of NH_3 and other amines due to the neutralization of the photoacid created during the exposure step will continue to be important for sub-0.18µm design rules as well. Thus, there are many advantages in reducing HMDS consumption both in terms of process and yield considerations and new environment health safety (EHS) requirements. In this paper, we present a quantitative correlation between the sub-0.18µm feature pattern collapse and the contact angle. The minimum CD line-width printability of UV5 resist on bare silicon wafers with different contact angles was characterized by using top down and cross section SEM images. Based on the results of this study, we propose a strategy for minimizing HMDS consumption for feature sizes > 0.2 µm and identify technology solutions in order to improve yield by minimizing pattern collapse.

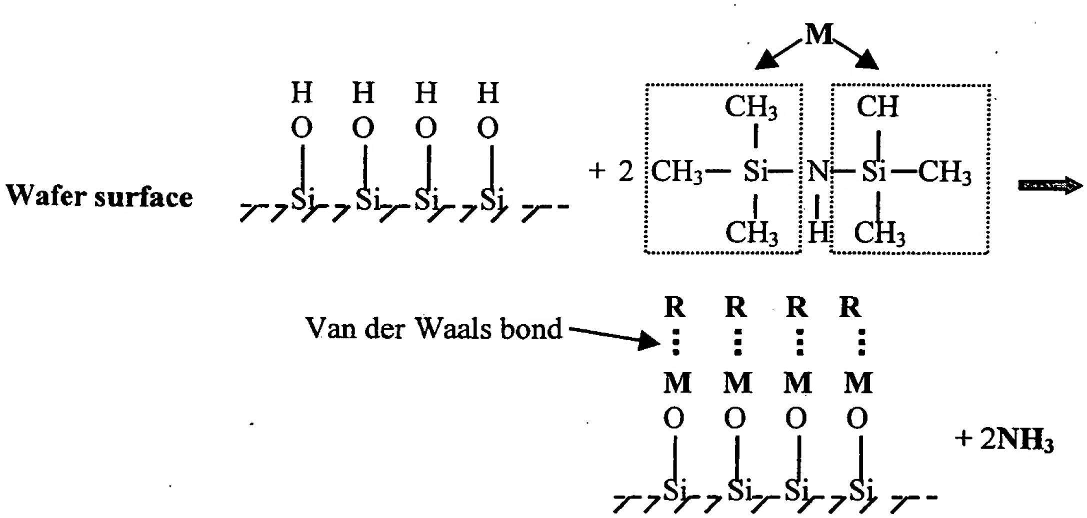
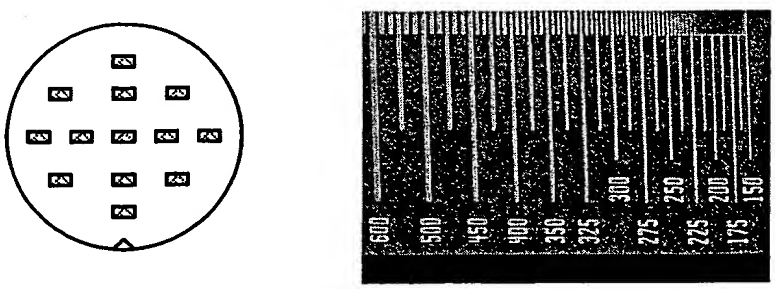


Figure 1. Reaction of HMDS with silanol groups on the wafer surface. **M** represents trimethylsilyl group and **R** resist molecules. Weak Van der Waals interaction between resist and trimethylsilyl group limits mechanical adhesion promotion property of HMDS. An NH_3 molecule, base contaminant for chemically amplified DUV resists, was generated for every HMDS molecule decomposed.

2. EXPERIMENTAL

Wafers with different contact angle were achieved by varying the prime time. HMDS prime performance was first evaluated. The correlation between wafer contact angle and uniformity and the prime time was established after processing statistically significant amount of wafers and measuring multiple points on each wafer. The approach undertaken in this study to examine minimum printable line-width was two folds: 1. Used constant dose and focus to pattern resist films with the die

distribution as shown in Figure 2(a) to check the minimum CD printability across the entire wafer. Figure 2(b) shows the pattern area on each die where the remaining smallest printed line was measured. Prime wafers were divided into four groups and each group was primed with 0s, 5s, 30s, and 180s respectively. Each wafer was coated with resist without interruption after priming. Prior to processing these wafers, a focus-exposure matrix wafer was first prepared to determine approximate dose at which a feature collapses for a wafer primed for 30s. All wafers were exposed with the dose to collapse determined from the focus – exposure wafer and developed with 45 seconds puddle time. After processing each wafer, the remaining smallest printed line was measured using a top down SEM images. 2. A 9x9 CD matrix with die distribution as shown in Figure 3 was used to determine the cross section CD profile and the minimum CD linewidth can be printed at different contact angle. A focus – exposure wafer primed with 30s prime time was first prepared to determine the dose to collapse for the 0.2μm isolated line in each die. Primed wafers with different contact angle were then coated and exposed with a dose matrix (9 steps with 0.5mj/cm^2 per step). The cross section profiles for each wafer were then characterized with SEM.



(a) (b)

Figure 2. CD pattern used to establish a correlation between the contact angle and minimum patterned feature size. (a) Die distribution on a wafer; (b) Pattern area to be observed for each die.

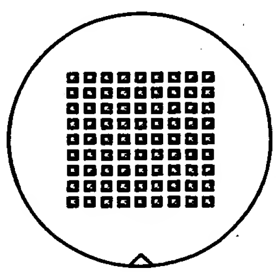
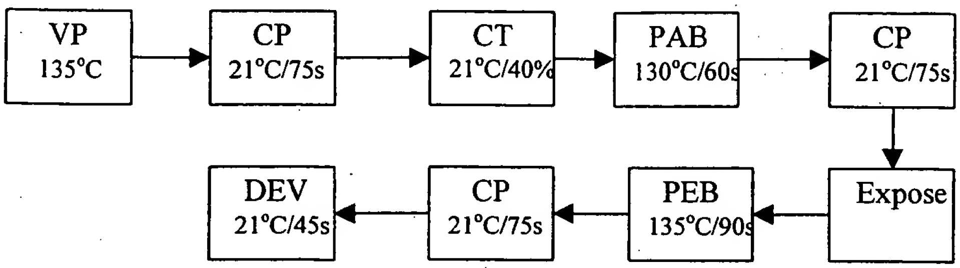


Figure 3. Die distribution for focus – exposure experiments.

2.1 Wafer Flow

All wafers were processed with the following flow and process variables:



VP- vapor prime, CP – chill plate, CT – coater (air temperature/relative humidity), PAB – post apply bake, PEB – post exposure bake, DEV – developer.

2.2 Materials

All wafers used in this study are prime wafers (from Silicon Quest International, 1Ω-cm) with ~ 20 Å native oxide. An ESCAP-based, chemically amplified UV5 resist (6cp) was used in all experiments. 100% HMDS priming agent (from Olin) was used in this study.

An SVG 248nm DUV photocluster comprised of an advanced SVG Track clustered with a SVGL Microscan II (NA=0.5) scanner was used in this study. Two different types of priming modules were used to confirm the results. An upgraded Hitachi S-806C scanning electron microscope (SEM) was used to analyze cross section profiles and top down images. All cross section dies were coated with a layer of gold by Desk II coater (Denton Vacuum). A Micro Vu Goniometer was used to measure contact angle.

3. RESULTS

Figure 4 shows contact angle and its uniformity as a function of prime time. Contact angle increases very fast within the first 3 seconds followed by a slower increase with time. Contact angle uniformity is better for short HMDS times and it increases slightly for 50 sec and drops for 180 sec. This characteristic dependence was reproduced for two different HMDS module geometries and it appears to be independent of details of air flow characteristics within the process module. These results indicate that the monolayer of silanol group on the wafer surface can be quickly replaced by the trimethylsilyl group and this reaction is not gated by HMDS concentration within the first few seconds. We calculated the HMDS consumption needed to form a monolayer of trimethylsilyl group on a 200mm wafer assuming that each Si atom on the <111> silicon wafer surface is an effective site for a trimethylsilyl group. Calculation result shows that minimum HMDS weight for 100% coverage is approximately 1.84×10^{-5}g HMDS per 200mm wafer to create such a monolayer. Measured HMDS consumption rate is about 0.01g/s. Because the amount of HMDS supply within one second is already more than 540 times larger than the required HMDS volume to form a monolayer of trimethylsilyl groups, mass transfer of HMDS to the silanol group is possibly the overall controlling step of the reaction rate in Figure 1. Especially, when a wafer surface is not perfectly flat as shown in Figure 5, a path to a silanol can be blocked by trimethylsilyl groups and it may require more energy and/or time for an HMDS molecule to break through the barrier to reach the silanol group. In the first few seconds, accessible silanol groups on the surface level will quickly adsorb trimethylsilyl groups. After all the accessible silanol groups on the surface are occupied, local variation in the uniformity of surface roughness may result in the observed time dependence of contact angle uniformity. Fast increase in the contact angle up to 10 sec of HMDS time followed by a slow increase also seems to support a similar reaction pathway scenario described in Figure 5.

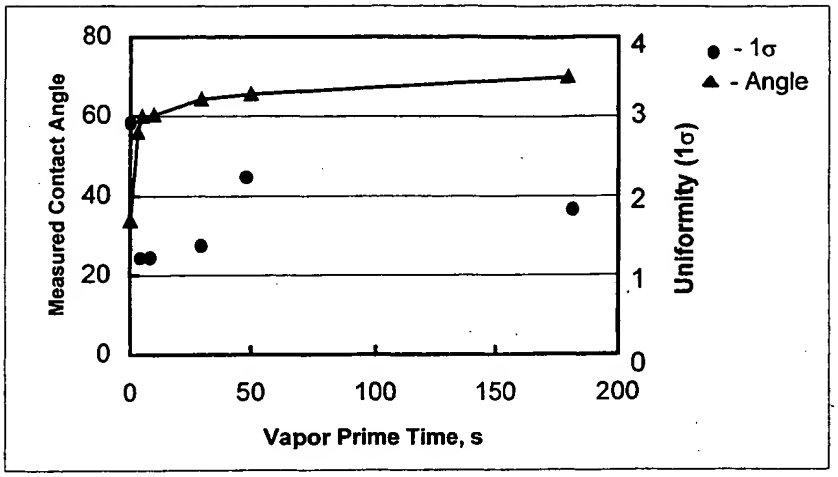


Figure 4. HMDS time dependence of contact angle and its uniformity.

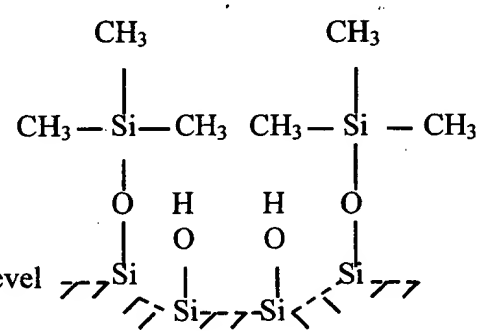
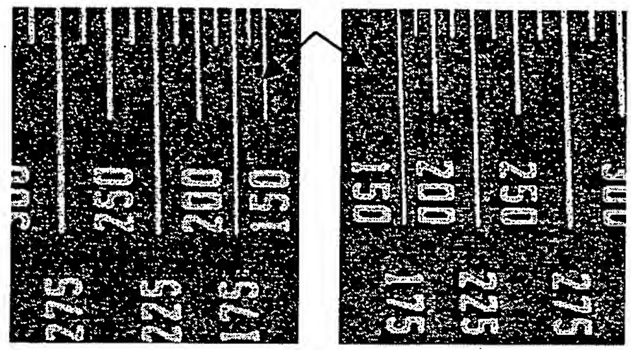


Figure 5. Path to silanol groups is blocked by preoccupied trimethylsilyl groups.

Figure 6 shows an example of top down SEM images observed under two different contact angles for an exposure dose of 9.5mj/cm^2 and it clearly shows the first clear evidence of contact angle and CD printability correlation. The 150nm reticle feature is patterned with contact angle of 70° and it is gone for 59°. Figure 7 shows the two dimensional patternability results across the wafer as a function of contact angles at a fixed dose of 9.5 mj/cm^2. Numbers in Figure 6 are the reticle line sizes and the actual line-width was measured using a top down CD SEM. For 150nm lines, the measured line-width is about 115nm and for 175nm lines, the measured linewidth is 135nm. These results clearly indicate a strong correlation between the smallest patterned feature size and contact angle. On the extreme case of wafers without HMDS process, contact angle is 34°, and majority of dies have washed away with the exception of few dies close to the HMDS port. Among those who remained on the wafer only very large features > 1μm survived. As the contact angle increases to 59°, mostly 135nm features were observed. The situation was reversed for the contact angle of 70° in that smallest printable feature size was 115nm with only two 135nm features remained for a dose of 9.5 mj/cm^2. There are more of 115nm features than 135nm at the intermediate 64° contact angle value. These results suggest that as the feature sizes become smaller, the contact angles need to get higher and requirement for the uniformity of contact angle will have to be tighter. The CD linearity for each wafer was measured to make sure that the difference of the smallest line patternability observed was due to contact angle variation. Figure 8 shows that the linearities for all three wafers are almost identical indicating that measured differences are vapor prime process related, as planned.



(a) (b)

Figure 6. Example of top down SEM images which show the smallest line printed. (a) An image for a wafer with 70° contact angle (b) a wafer with 59° contact angle. Note the 150nm (115 nm on the wafer) feature is only visible with 70° contact angle.

Cross sectional SEM profiles were used in order to further correlate the pattern collapse and contact angles for features smaller than 0.18μm. Exposure doses were incrementally increased till maximum dose above which patterns collapse was observed. Focus adjustment resulted in the trapezoidal CD profile shown in Figure 9 which was intentionally used in order to prevent features from collapsing due to factors other than adhesion failures. Again, most dies were washed away using wafers without priming process with only features >1μm remaining. Figure 10 shows a typical cross section profile with severe undercut for a wafer with insufficient prime. Figure 11 shows cross section CD profile progression as dose increases for different contact angles. Overexposed features start collapsing as they become thinner with increasing dose at a critical contact angle value. Pattern collapse takes place at a higher dose, meaning smaller line-width with increasing contact angle. These results are in agreement with Figures 6 and 7. The average line-width measured from cross-section profiles are about 0.132μm, 0.125μm, and 0.115μm for 59°, 64°, and 70° respectively.

4. DISCUSSION

These results provide additional insight for the mechanism of pattern collapsing. Weak Van der Waals interaction between the trimethylsilyl group and resist means that HMDS adhesion promotion is not because of the increased bonding strength between the resist film and the substrate. It has been shown that HMDS priming agent functions as an adhesion promoter by preventing aqueous solutions such as developer, and deionized water from penetrating the interface between the substrate and the resist film during the develop process.[2] Michielsen et al established the correlation between the contact angle as a function of surface coverage of trimethylsilyl groups using TOF SIMS as shown in Figure 12.[2] According to this graph, the surface coverage of trimethylsilyl is almost linearly proportional with contact angle between 30° to 90° and about 30% of the wafer surface is not covered by trimethylsilyl groups at a contact angle of 70°. This suggests that the distance developer fluid must penetrate the photoresist-substrate interface before failure of the pattern may only be on the order of a few tens of nanometers.[5] Figure 13 shows a possible pattern collapse scenario due to insufficient HMDS priming as feature sizes decrease toward 0.18μm and 0.13μm. A feature shown in Figure 13(a) is protected from both sides by the trimethylsilyl groups, corresponding to a high contact angle case and it is the least likely feature to collapse. A feature with one side of the resist-substrate interface is not protected by the trimethylsilyl group against developer or DI water is shown in Figure 13(b). Whether or not this feature actually collapses will depend on the protected critical dimension labeled D. Pattern collapse is more likely as D gets smaller. Figure 13(c) shows a feature with both sides of the resist-substrate is un-protected by trimethylsilyl group. In the extreme case of a very small contact angle and D=0, a feature may reside on a gap without trimethylsilyl group supporting it, as shown in Figure 13(d). Different level of HMDS priming as measured with contact angle can create a distribution of sites similar to the cases shown in Figure 13. It is clear that as we continue reducing the line-width the likelihood of pattern collapse will increase for cases shown in Figure 13(d) first followed by 13(b) and 13(c) depending on CD and the protected dimension D. Chemically speaking, pattern collapse is likely if an aqueous solution can penetrate the resist-substrate interface.

In addition to this chemical component of pattern collapsing mechanism, mechanical impact during the develop and rinse process may also cause pattern collapsing of small features. Figure 14 shows calculated impact force on the resist features of varying size for a standard single stream nozzle and a new low impact nozzle.[6] Enhancements in the nozzle designs can reduce the impact force by a factor of 4-5 for 100-180nm device features.

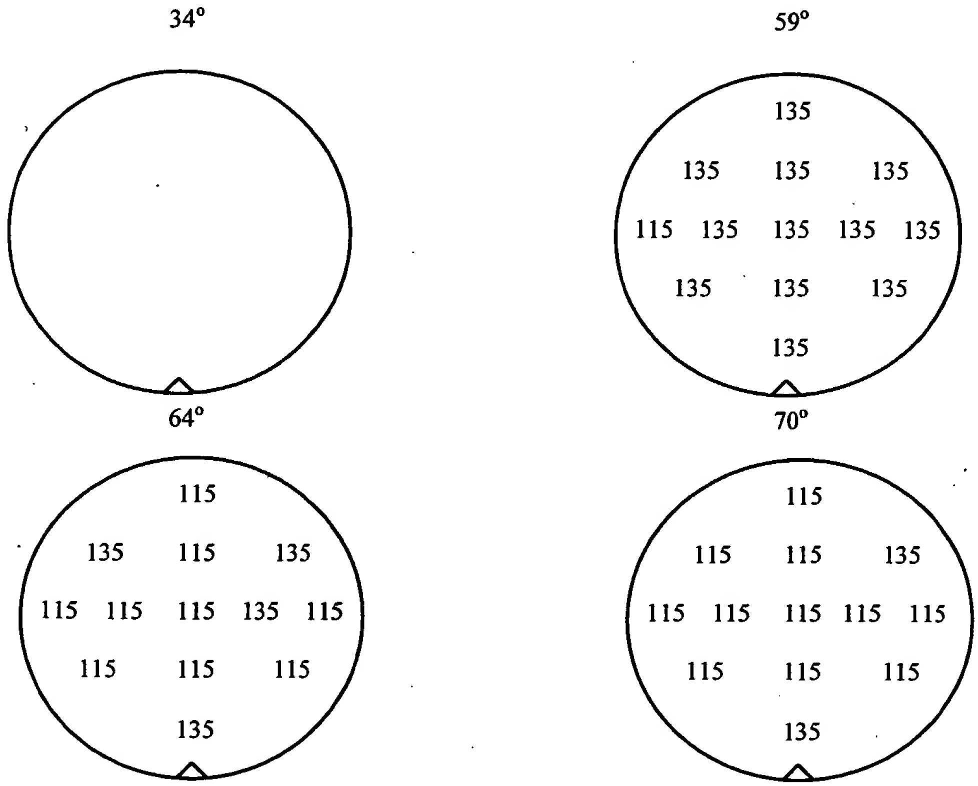


Figure 7. The minimum isolated lines printed at a dose of 9.5mj/cm^2 on wafers primed with different contact angles. The 34° contact angle wafer did not go through any priming process and consequently all features except > 1µm were washed away due to pattern collapsing. The smallest 115nm feature size requires contact angle of 70 degrees.

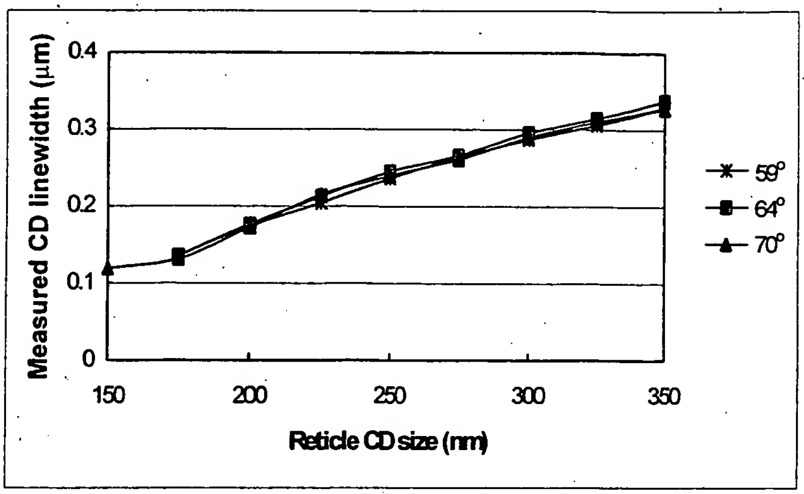


Figure 8. CD linearity of wafers with different contact angle.

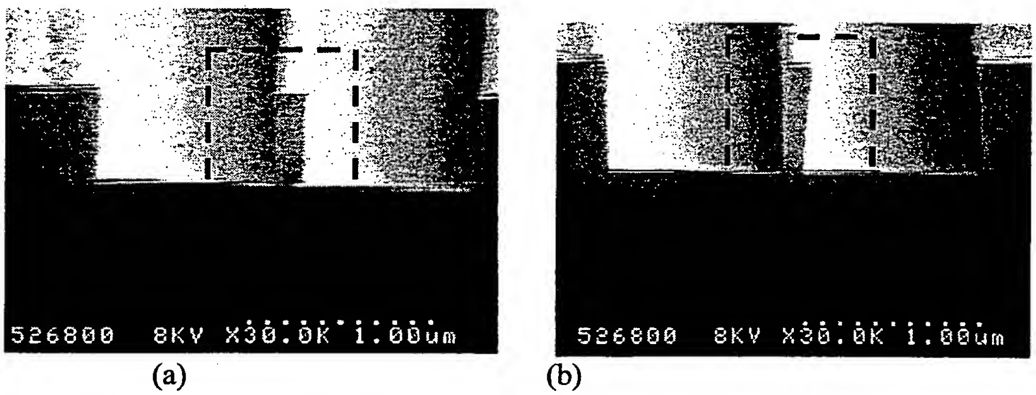


Figure 9. Cross section profile gets smaller as the dose increases. (a) 0.2µm line was exposed with 12mj/cm^2. (b) 0.2µm line was exposed with 14mj/cm^2.

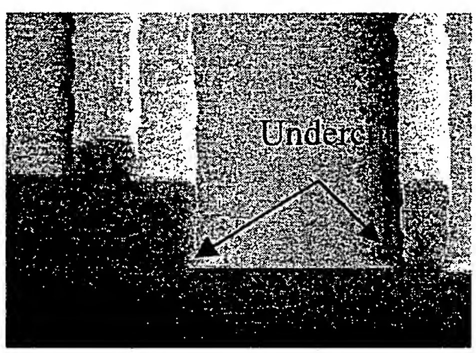


Figure 10. Typical cross section profile for features with insufficient prime.

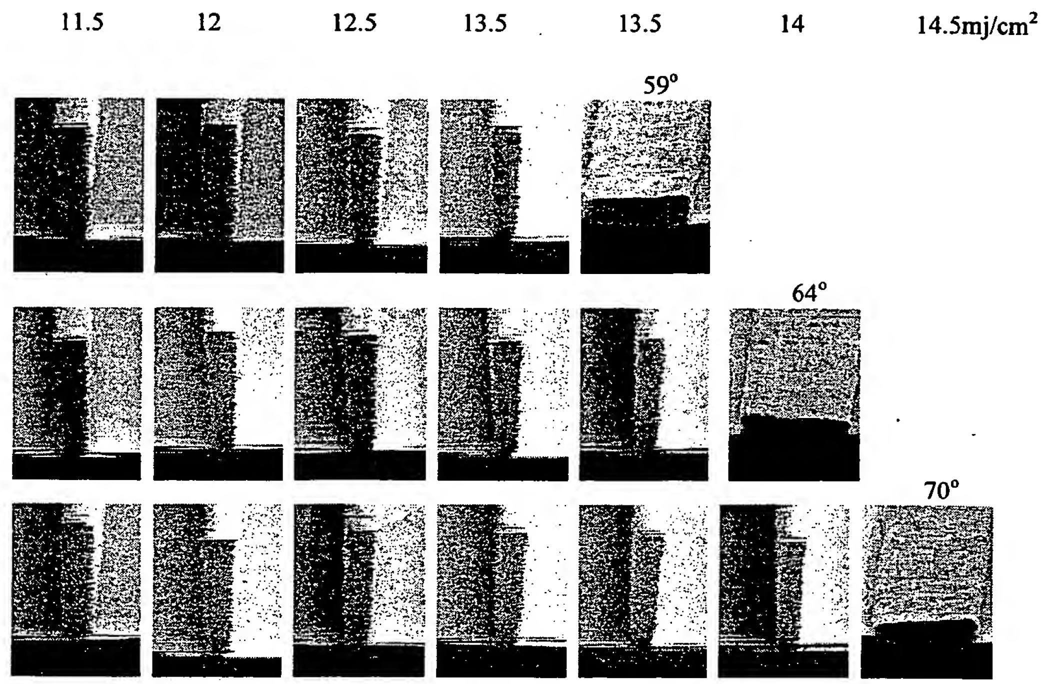


Figure 11. Cross section CD profiles as a function of contact angle and exposure dose. Thinner lines stand only with increasing contact angle.

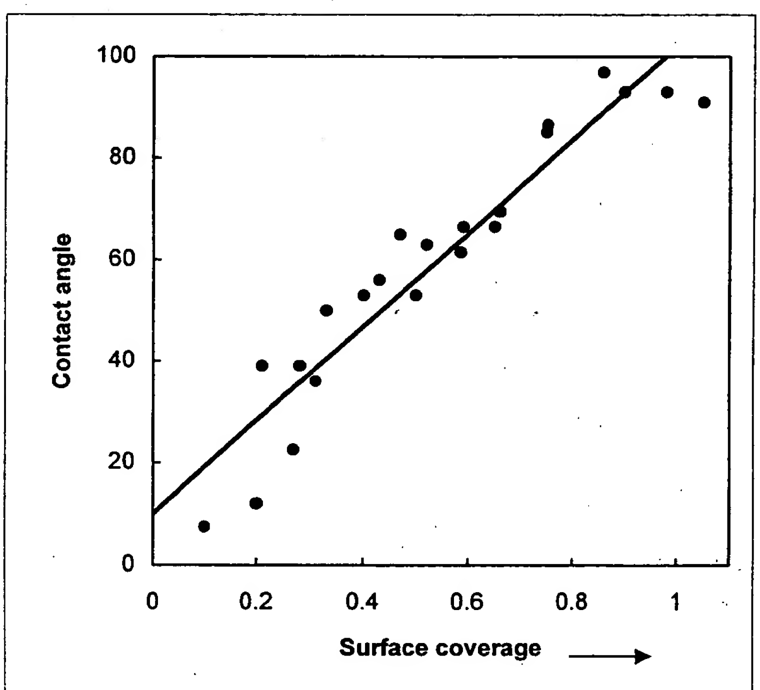


Figure 12. Contact angle as a function of surface coverage of trimethylsilyl groups as measured with TOF SIMS (ref. 2).

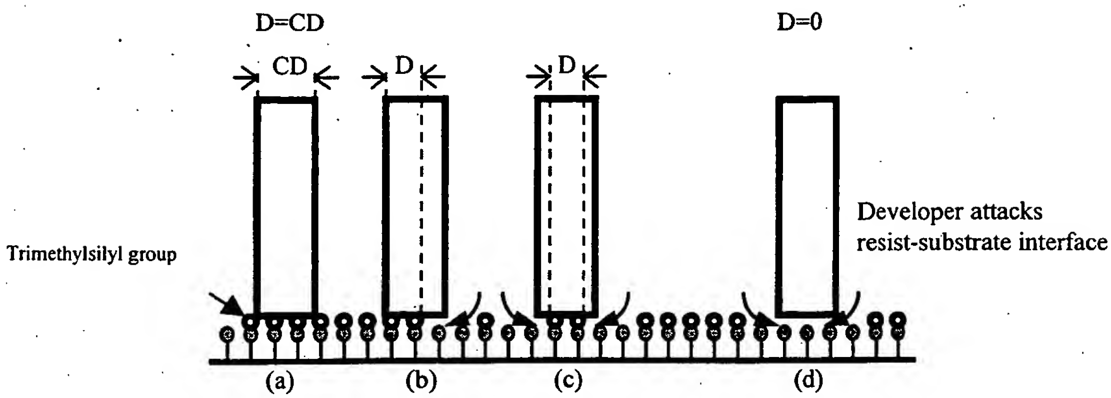


Figure 13. Possible mechanistic scenarios for pattern collapse due to insufficient priming. (a) . Resist – substrate interface is fully protected by trimethylsilyl group. (b) Resist – substrate interface is partially protected. Aqueous solution can attack this feature from right hand side. (c) Resist – substrate is partially protected. Aqueous solution can attack this feature from both sides. (d) The entire resist – substrate interface is not protected, the most likely candidate to collapse

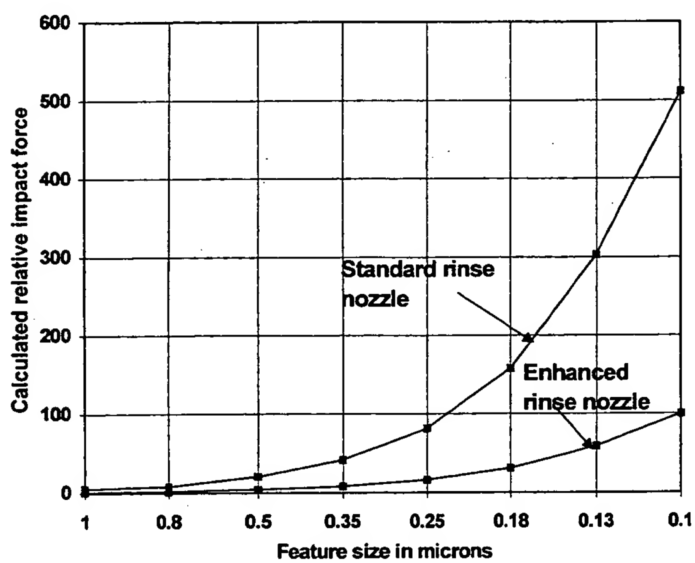


Figure 14. Calculated impact force on feature size for standard and enhanced low impact nozzle. (ref.6)

5. CONCLUSIONS

Exposure and PEB processes are usually considered to be very critical for DUV lithography because of photochemical reactions initiated by the absorption of photons. They, along with the resist material, have a great impact on the ultimate resolution for a litho cluster. Similarly, coat, exposure, PEB and develop processes all have an impact on the CD control challenge of the next generation devices. In the era of sub-wavelength lithography, characterized by decreasing imaging layer thickness, interaction of the substrate surface and resist film becomes increasingly important and additional processes

such as vapor priming play an important role for improved yield. In this paper we were able to demonstrate a clear correlation between the smallest patternable feature size and contact angle by using both top down and cross section SEM results. Three dimensional 115nm isolated lines could only be patterned if contact angles were about 70° or above under our experimental conditions. Proposed pattern collapse mechanisms under insufficient HMDS priming conditions include aqueous solutions of develop process penetrating the surface-resist interface and destroying adhesion capability of the resist film.

Calculated minimum HMDS consumption for 100% coverage is 1.84×10^{-5} g for a Si <111> surface and measured consumption rate is 0.01 g/sec. Based on our results, HMDS consumption can be reduced by 66% if HMDS time is lowered to 10 sec for critical layer design rules of 0.2 µm and above. For features < 0.2 µm 10-30 sec HMDS process timing may be advisable to prevent pattern collapsing. A new priming agent material could be very useful in attaining higher contact angles with smaller priming time for feature sizes < 0.1 µm.

One potential design improvement to minimize pattern collapse resides in the developer module where actual failure takes place. An integrated low impact developer and DI water nozzle system has been developed specifically for sub 0.2 µm device geometries. [7] In addition to its particle and defect reduction and CD control advantages, this new nozzle reduces the impact force by a factor of 4-5 for 100-180 nm features as compared to the standard nozzle which was used in this work, as shown in Figure 14. [6,8] New SVG photoresist processing system ProCell™, designed for 100-180nm geometries, has many new features relevant to the topics discussed in this paper. They include low impact developer and rinse yield and CD improvement system mentioned above, advanced HMDS module design for maximum contact angle and uniformity and minimum ammonia background, improved system chemical filtration and air flow management. In addition, advanced layout of ProCell™ decouples the develop portion of Track system from the coat portion thus improves the pattern integrity of developed features by physically isolating exposed DUV resists from potential amine residues. ProCell™ platform features many original technical enhancements in order to extend 248nm DUV technology towards 100nm design rules.

ACKNOWLEDGMENT

The authors thank John Salois for his support of the equipment and lab used in this study.

REFERENCES

1. K. L. Mittal, "Factors Affecting Adhesion of Lithographic Materials", Solid State Technology / 89, May. 1979.

2. M.C.B.A. Michielsen, V.B. Marriott, J.J. Ponjee, H. van der Wel, F.J. Touwslager, J.A.H.M. Moonen, "Priming of Silicon Substrates with Trimethylsilyl Containing Compounds", Microelectronic Engineering, Vol. 11, 475-480, 1990.

3. H. Yanazawa, N. Hashimoto, "Chemical Characterization of Photoresist to SiO2 Adhesion in Intergrated Circuit Technologies" Kodak Microelectronics Seminar Proceedings, Interface 77, 153-160, 1977.

4. C. M. Dai, D. H. Lee, "Studies on the Adhesion Contact Angle of Various Substrates and their Photoresist Profiles", SPIE Vol. 2438/709, 1995.

5. P. M. Dentinger, J. W. Taylor, "The Importance of Chemistry at the Resist-Wafer Interface for Mechanical and Lithography Adhesion." SPIE Vol. 2723/249, 1996.

6. M. Krishna, E. Gurer, T. Zhong, E. Lee, J. Salois, R. Reynolds, " Integrated Yield & CD Enhancement for Advanced DUV Lithography", Process, Equipment & Materials Control in IC Manufacturing, 1999

7. Patent pending.

8. M. Krishna, E. Gurer, E. Lee, G. Flores, S. Ooka, J. Salois, R. Cherry, R. Reynolds, "Reduction of post-develop defects and process times for DUV lithography", Proc. Of SPIE, 1999.